



EFFECT OF DROUGHT STRESS ON EARLY GROWTH OF *Adansonia digitata* (L.) IN SEMI-ARID REGION OF NIGERIA

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ABSTRACT

Drought and high temperatures are said to have triggered increased tree mortality and could be linked to the menace of climate change. This research therefore investigated the effect of drought stress on early growth of Adansonia digitata where seedlings were exposed to different watering frequencies (Once daily, after 3, 7 and 14 days) using 200ml of water per seedling for twelve weeks. A completely randomized design was used and data was collected on stem height, collar diameter, leaf production and seedling dry weight. Relative growth rate, net assimilation rate and absolute growth rate were calculated and the data was analyzed with analysis of variance (ANOVA) and significantly different means were separated with Duncan Multiple Range Test [DMRTs (0.05)]. Result showed significant effect on early growth of A. digitata where seedlings that received water once daily and once after three days had the highest growth in all the variables assessed. Watering once after three days is recommended for the production of A. digitata seedlings.

Key word: Drought stress, Seedling growth, *A. digitata*

INTRODUCTION

Forest resources play a significant role in the national economy of many countries in the tropics and vegetation generally serves as a good conserver of soil water by encouraging percolation and discouraging run-off (Mukhtar, 2016). This notwithstanding, drought and high temperatures are said to have triggered increased tree mortality and could be linked to the menace of climate change (Allen *et al.*, 2010 and Olajuyigbe *et al.*, 2012). Recently, tropical forest areas are reported to have experienced a dramatic decrease in annual rainfall and an increase in the length of dry season (Olajuyigbe *et al.*, 2012). It is therefore important to investigate the mechanism of drought tolerance in forest species, in order to understand and predict their responses to climate change (Olajuyigbe *et al.*, 2012). In order to promote sustainable use of water in the nurseries, it is paramount to establish optimal water requirements for tree seedlings (Simon *et al.* 2011). This helps in reducing the cost of planting stock production in commercial nurseries. Despite the need to

establish optimum water requirement for trees, the information on the indigenous semi arid trees is limited (Simon *et al.* 2011) and this constrains local nursery operators to make informed management decision on their operations.

MATERIALS AND METHODS

The study was carried out in Aliero area of Kebbi State, Nigeria (latitude 12°16'42"N and Longitude 4°27'6"E) which covers an area of about 350km² (Olajuyigbe *et al.*, 2012). Aliero is inhabited by an agrarian community with special interest in onion and pepper farming. The area is dominated by two distinctive seasons: the wet season (May-September) and the dry season (October-April) with mean annual rainfall of about 800mm and temperatures of about 26°C. Although, the temperature can go down to about 21°C during the harmattan and up to 40°C between April and June (Mukhtar, 2016). The natural vegetation of Aliero is Sudan savanna. Two weeks old seedlings were randomly selected and subjected to four different watering

frequencies (Once daily, once after 3, 7 and 14 days) (Olajuyigbe *et al.*, 2012). Ten seedlings were allocated per watering frequency and were replicated five times making a total of 50 seedlings per watering frequency in a completely randomized design and each seedling was given 200ml of water based on the watering frequency in the morning. The growth variables measured were: seedling stem height, collar diameter and number of leaves. A meter rule was used to measure height (mm), micro-meter screw gauge for diameter and number of leaves was counted. Biomass (seedlings dry weight) was assessed at the 6th and 12th weeks of the experiment through destructive method (Aderounmu, 2010). Leaf area was measured by tracing the area covered on graph sheet. Fresh weight of root, stem and leaves were measured before they were oven dried at 80°C to constant weight. The dry weight and leaf area were used to calculate the relative growth rate, net assimilation rate and absolute growth rate using the following formula by Aduradola *et al.* (2014).

Net Assimilation rate (NAR)

$$NAR = \frac{w_2 - w_1 \times \ln A_2 - \ln A_1}{A_2 - A_1 \times t_2 - t_1}$$

Where,

w_1 and w_2 = biomass at time t_1 and t_2

A_1 and A_2 = leaf area at time t_1 and t_2

$\ln A_1$ and $\ln A_2$ = natural logarithm of leaf area at time t_1 and t_2

Relative Growth Rate (RGR)

$$RGR = \frac{\ln w_2 - \ln w_1}{t_2 - t_1}$$

where, $\ln w_2 - \ln w_1$ = natural logarithm of biomass at time t_1 and t_2

t_1 and t_2 = time interval between first and second harvest

Absolute Growth Rate (AGR)

$$AGR = \frac{w_2 - w_1}{t_2 - t_1}$$

where, w_1 and w_2 = biomass at time t_1 and t_2

t_1 and t_2 = time interval between first and second harvest

RESULTS

Height

Seedlings watered once after 3 days had significantly ($P < 0.05$) higher stem height (21.10cm) followed by seedlings that were watered once daily (19.00cm) and differed significantly with watering once after 7 and 14 days as shown in Figure 1.

Diameter

Figure 2 shows the mean diameter growth of seedlings as influenced by various watering frequencies with the largest diameter (9.94mm) obtained from seedlings watered once daily which differed significantly ($P < 0.05$) with seedlings watered once after 14 days (5.51mm).

Number of leaves

Watering frequency had significantly ($P < 0.05$) influenced seedlings leaf production. At 12th week after emergence seedlings watered once daily had significantly ($P < 0.05$) higher number of leaves (12mm) than seedlings watered once after 14 days (1mm) as shown in table 1.

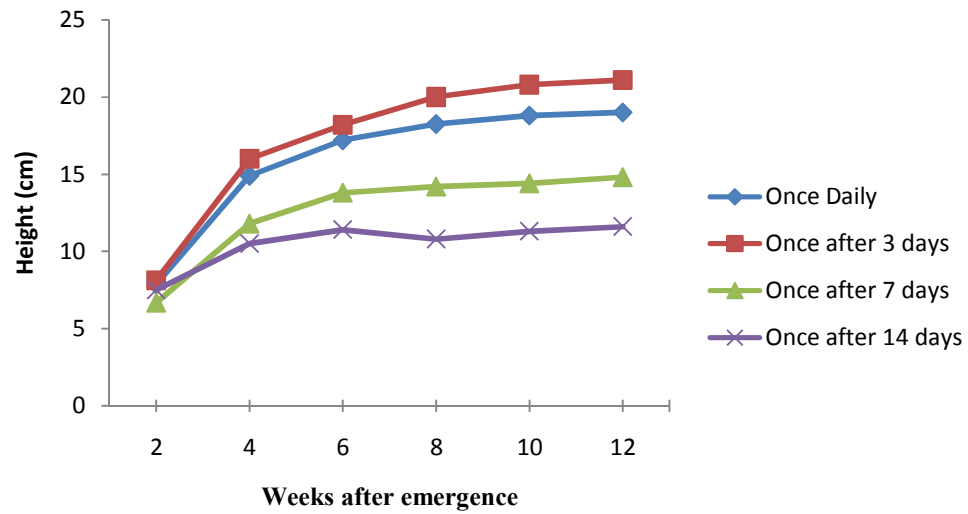


Figure 1: Effect of watering frequency on seedlings height of *A. digitata*

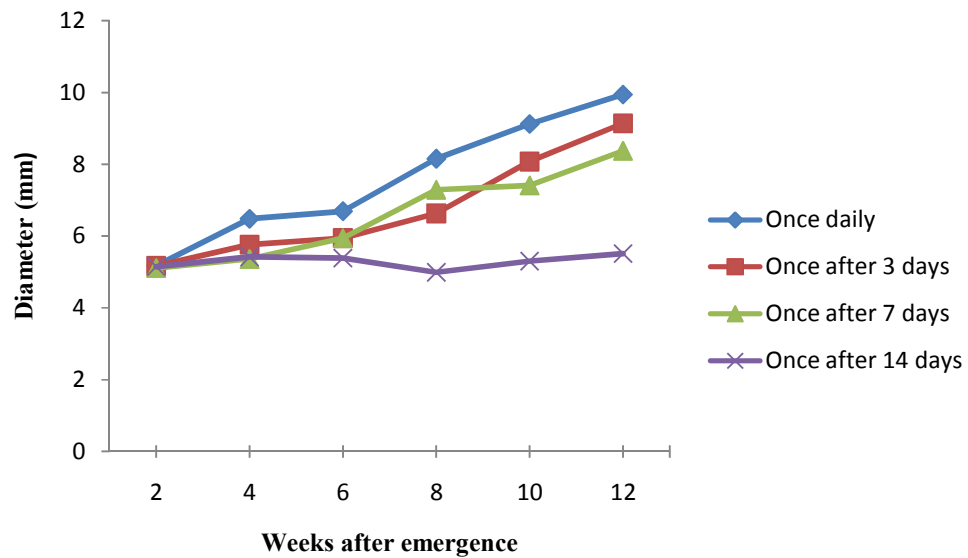


Figure 2: Effect of watering frequency on seedlings diameter of *A. digitata*

Table 1: Effect of watering frequency on leaf production of *A. digitata* seedlings

| Treatment | Number of Leaves | | | | | |
|--------------------|------------------|-----------------|-----------------|-----------------|------------------|------------------|
| | 2WAE | 4WAE | 6WAE | 8WAE | 10WAE | 12WAE |
| Once daily | 5 ^b | 8 ^a | 12 ^a | 11 ^a | 12 ^a | 12 ^a |
| Once after 3 days | 6 ^a | 10 ^a | 12 ^a | 11 ^a | 10 ^{ab} | 10 ^{ab} |
| Once after 7 days | 6 ^{ab} | 8 ^a | 10 ^a | 10 ^a | 8 ^b | 8 ^b |
| Once after 14 days | 5 ^{ab} | 6 ^b | 6 ^b | 3 ^b | 2 ^c | 1 ^c |
| S.E ± | 0.181 | 0.423 | 0.721 | 1.005 | 0.987 | 1.037 |
| Significance | * | * | * | * | * | * |

Means followed by the same letter(s) within a column are not significantly different ($P>0.05$)

WAE: Week after emergence

Leaves Dry Weight (LDW)

No significant effect was observed on LDW and seedlings watered once daily had LDW of 2.20g but was not significantly ($P>0.05$) different from watering once after 14 days (Figure 3).

Stem Dry Weight (SDW)

Watering frequency had significant ($P<0.05$) effect on SDW where seedlings that received water once in a day had higher SDW (2.50g) which significantly ($P<0.05$) differed from seedlings watered once after 14 days (Figure 3)

Root Dry Weight (RDW)

Figure 3 shows mean RDW of seedlings exposed to various watering frequencies where those watered once daily had the highest RDW (4.60g) and differed significantly ($P<0.05$) with watering once after 7 and 14 days.

Total Dry Weight (TDW)

A graphical representation of seedlings exposed to different watering frequencies is shown in figure 3 where seedlings watered once daily and once after 3 days (9.30g and 4.50g) differed ($P<0.05$) from watering once after 7 days.

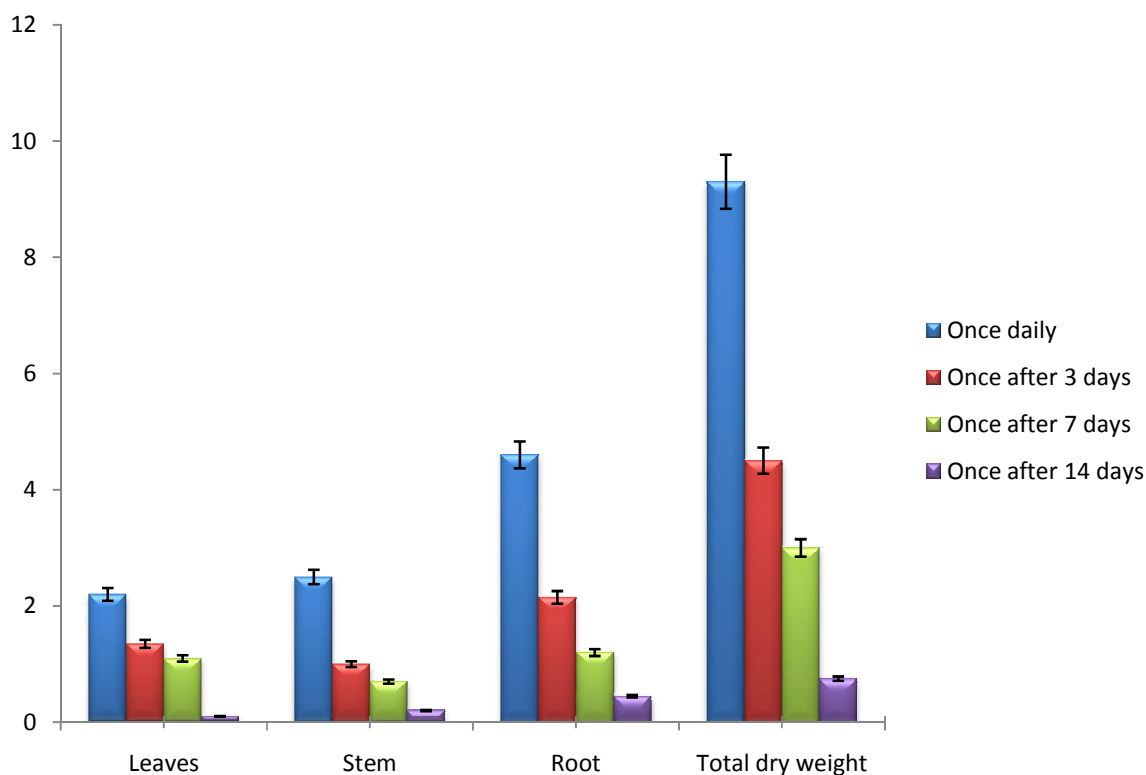


Figure 3: Effect of watering frequency on seedlings dry weight (g) of *A. digitata*

Leaf Area

The highest leaf area was obtained from seedlings exposed to watering once in a day (57.36cm^2) which was followed by once after 3 days (31.50cm^2) and both were significantly ($P>0.05$) different from watering once after 14 days (9.75cm^2) (Figure 4).

Net Assimilation Rate (NAR)

Table 14 shows the mean NAR of seedlings exposed to different watering frequencies where watering once daily had significantly higher NAR (0.00359) while once after 14 days had the least (0.00042).

Relative Growth Rate (RGR)

A significant effect was recorded in seedlings RGR between 4th and 12th week after emergence where seedlings watered once daily had higher RGR (0.04003) which was significantly ($P<0.05$) different with watering once after 3 and 14 days (Table 2).

Absolute Growth Rate (AGR)

AGR was significantly ($P<0.05$) influenced by watering frequency (Table 2). Watering once daily had significantly higher AGR (0.14910) between 4th and 12th week after emergence and seedlings watered once after 14 days had the least AGR (0.00535) (Table 2).

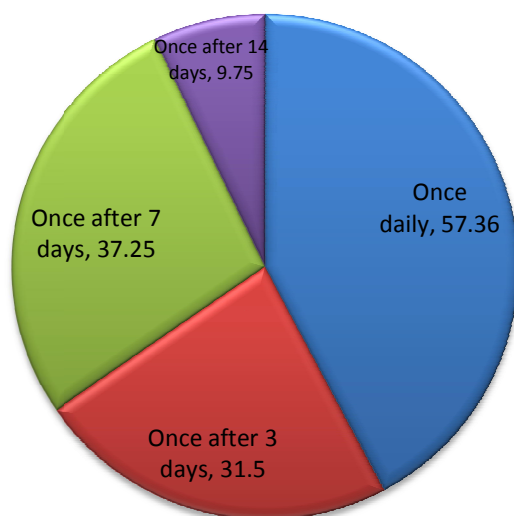


Figure 4: Effect of watering frequency on leaf area (cm^2) of *A. digitata*

Table 2: Effect of watering frequency on seedlings NAR, RGR and AGR of *A. digitata*

| Treatment | NAR | RGR | AGR |
|--------------------|-----------------------|----------------------|----------------------|
| Once daily | 0.00359 ^a | 0.04003 ^a | 0.14910 ^a |
| Once after 3 days | 0.00124 ^{bc} | 0.01251 ^b | 0.04107 ^b |
| Once after 7 days | 0.00159 ^b | 0.03190 ^a | 0.04464 ^b |
| Once after 14 days | 0.00042 ^c | 0.00912 ^b | 0.00535 ^b |
| S.E | 0.00045 | 0.00499 | 0.02218 |
| Significance | * | * | * |

Means followed by the same letter(s) within a column are not significantly different ($P>0.05$)

NAR: Net assimilation rate, RGR: Relative growth rate, AGR: Absolute growth rate

*Significant

DISCUSSION

Watering frequency was found effective in improving early growth of *A. digitata* where watering once daily and once after three days encouraged highest growth over other watering frequencies. *A. digitata* can be referred to as drought tolerant species as seedlings that were watered once after fourteen days survived throughout the period of the experiment, although they had a very low growth. This is confirmed by De Smith *et al.* (2011) and Larwanou (2014) that *A. digitata* seedlings have capacity of maintaining high water status in drought events which help to prevent xylem cavitations and this is why the species survives dry periods. Watering once daily and once after three days had similar result in all the growth parameters assessed. This partly confirmed the result of Isah *et al.* (2013) on *Acacia senegal* where seedlings watered once in three days had the highest growth over some that were watered once daily, twice a day and once in two days. Although in this research seedlings watered once daily yielded higher growth (stem height, collar diameter, leaves and biomass) but was not statistically different to those watered once after three days. Seedlings that were exposed to watering once after fourteen days survived but most of their leaves were shed and the stem became slim and this can be explained by the work of Olajuyigbe *et al.* (2012) that deciduousness forced on the species is an important component of drought tolerant strategy which de-emphasized leaf production under low water supply. This confirmed Sale's work (2015) that water stress is said to affect physiological function of a tree crop thereby influencing growth and yield. The findings are in line with the result of Akinyele (2007) who reported highest growth in seedlings of *Buchholzia coreacea* watered once daily. The result also agreed with Larwanou (2014) who recorded highest growth of seedlings of *Moringa oliefera* and *A. digitata* that were watered once after two days and once after four days over the seedlings

that received water once and twice daily but the only disagreement being that seedlings that were watered once daily in this research produced the high growth, even though not different with watering once after three days. Subairu (2014) and Oyun *et al.* (2010) recorded highest growth in seedlings of *Acacia senegal* that were watered twice a week compared to daily and biweekly watering and this is similar to the findings of this research. These findings disagreed with the work by Olajuyigbe *et al.* (2012) where no significant difference was reported in seedlings of *D. mespiliformes* in all watering regimes (once daily, once after 7 and 14 days) with regards to stem height and leaf production. This could be due to differences in water requirements. The result from this work suggests that *A. digitata* is a drought tolerant species even though high growth was obtained from seedlings watered once daily but was similar to those watered once after three days. Therefore for reduced cost of production and enhanced growth in nurseries, watering once after three days is recommended for *A. digitata*. For reduced cost of production and growth, seedlings of *A. digitata* should be watered once after 3 days (200ml).

CONCLUSION

Watering once daily and once every three days produced the highest growth rates in *A. digitata* for all parameters assessed. *A. digitata* seedlings proved to be resistant to drought treatment since the seedlings were able to survive without watering for all the watering regimes even though drought reduced leaf area as well as collar diameter and total biomass.

RECOMMENDATION

Watering once after three days with 200ml is recommended for optimum and economic growth of *A. digitata* seedlings.

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